

**Faculty of Engineering and Technology**

**Electrical and Computer Engineering Department**

**Communication Lab - ENEE4113**

**Prelab for experiment (1)**

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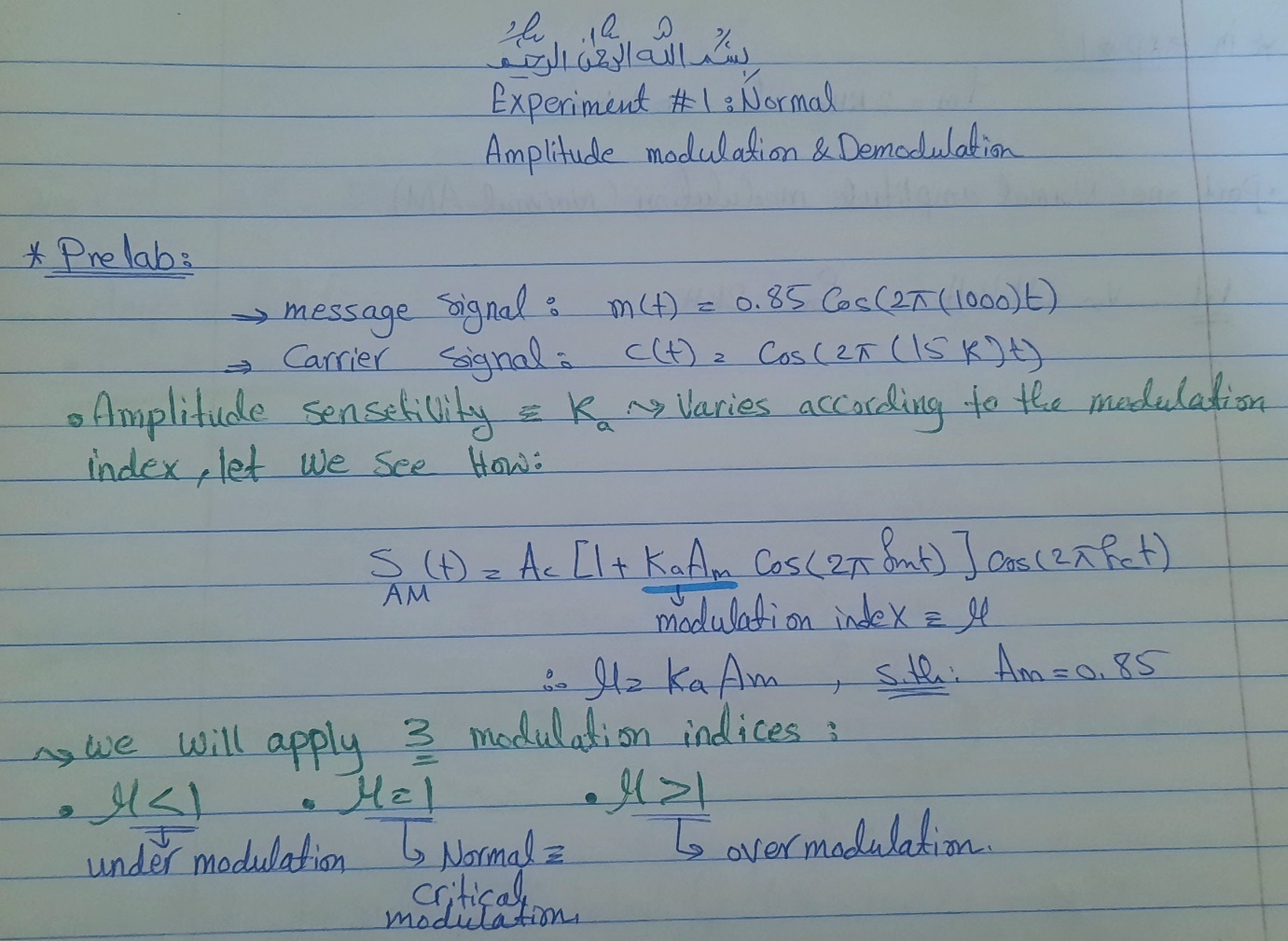
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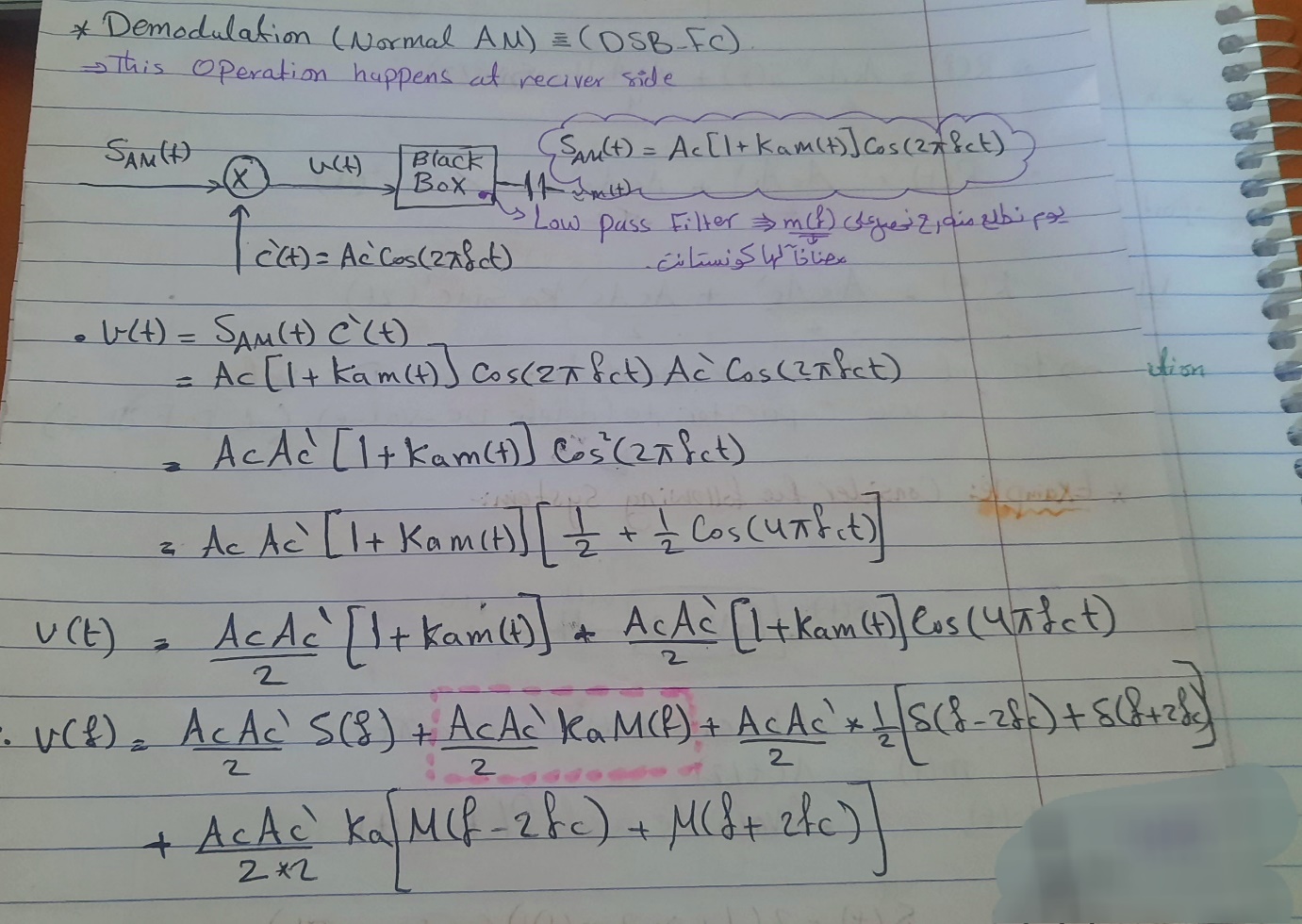
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# **Theoretical Prelab:**

**Review the theoretical background of the Normal Amplitude Modulation and Demodulation (Please give a detailed view on the mathematical (equations) side).**

The mathematical representation of an AM signal can be given as:





# **Software Prelab (LabVIEW (Simulink) ):**

Build a full simulation block diagram of the modulation and the demodulation of the Normal AM that shows both the time and frequency domains.

The diagram must show (message, carrier, modulated and demodulated) signals. Use two demodulation methods (coherent and envelope detector). Take into consideration to run your diagram for 3 modulation indices (μ<1, μ=1, μ>1 ). Show the parameters you have used in each block.

Message signal: 𝑚(𝑡) = 0.85cos(2𝜋(1000)𝑡)

Carrier signal: 𝑐(𝑡) = 1cos(2𝜋(15𝑘)𝑡)

## **Block Simulation (MATLAB Simulink)**

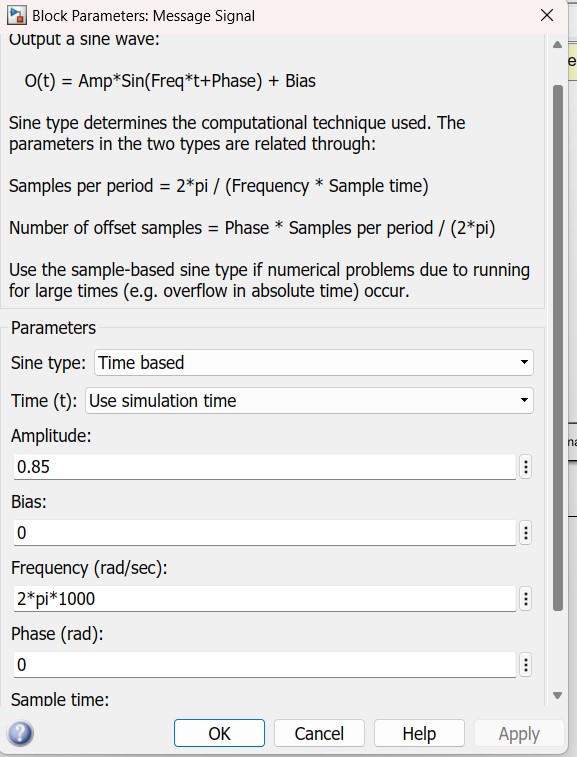
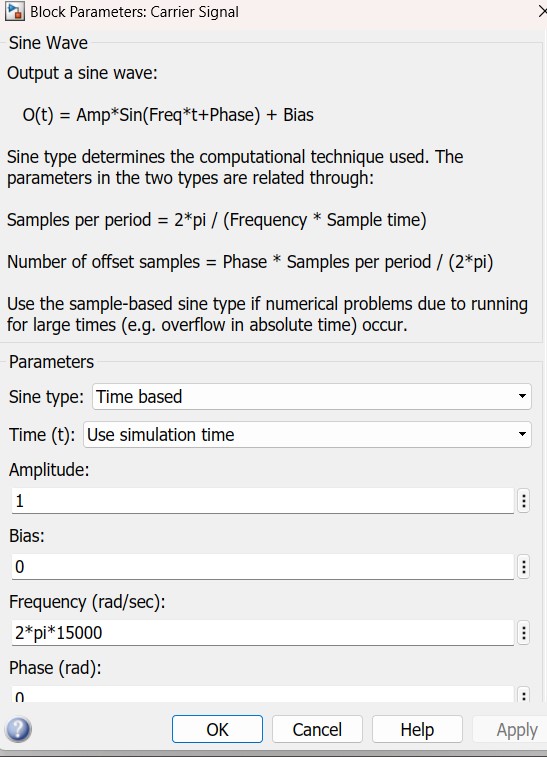


Figure 1:message and carrier signal parameter

# **Modulated signal normal AM**

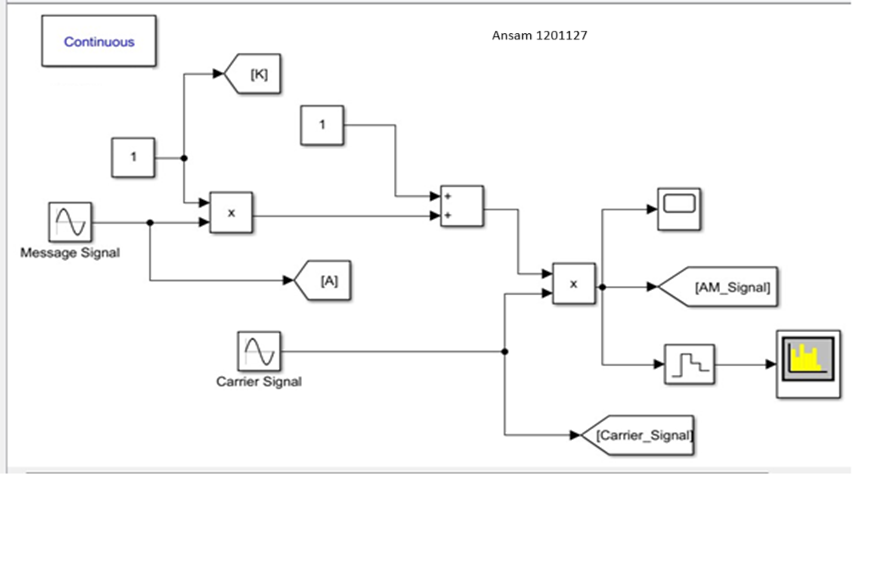


Figure 2:: Normal AM Block

𝑚(𝑡) = 0.8cos(2𝜋(1000)𝑡).

Spectrum of m(t) = 0.  δ(𝑓 − 1000)+ 0.  δ(𝑓 + 1000)

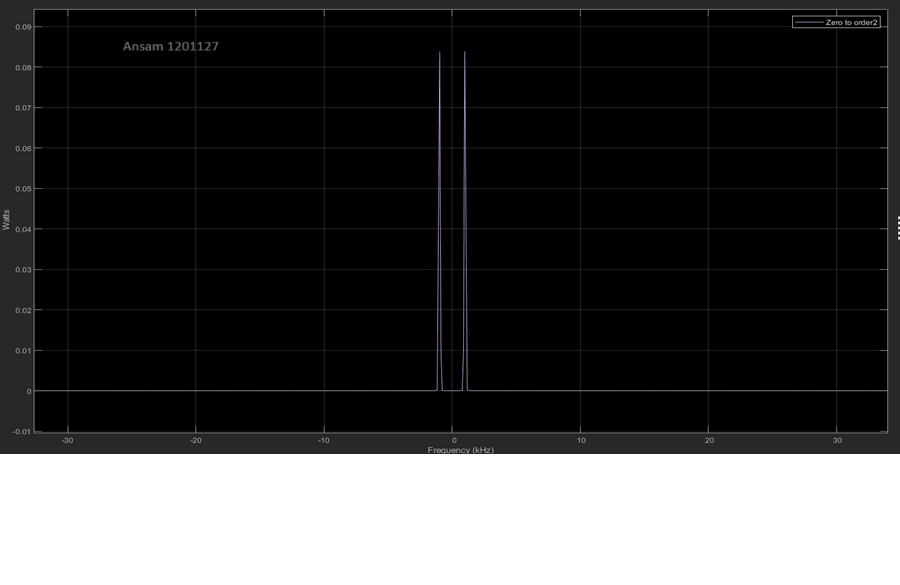


Figure 3:spectrum of m(t)

Carrier signal : 𝑐(𝑡) = 1cos(2𝜋(15𝑘)𝑡)

Spectrum of c(t) =  δ(𝑓 − 15000)+  δ(𝑓 + 15000)

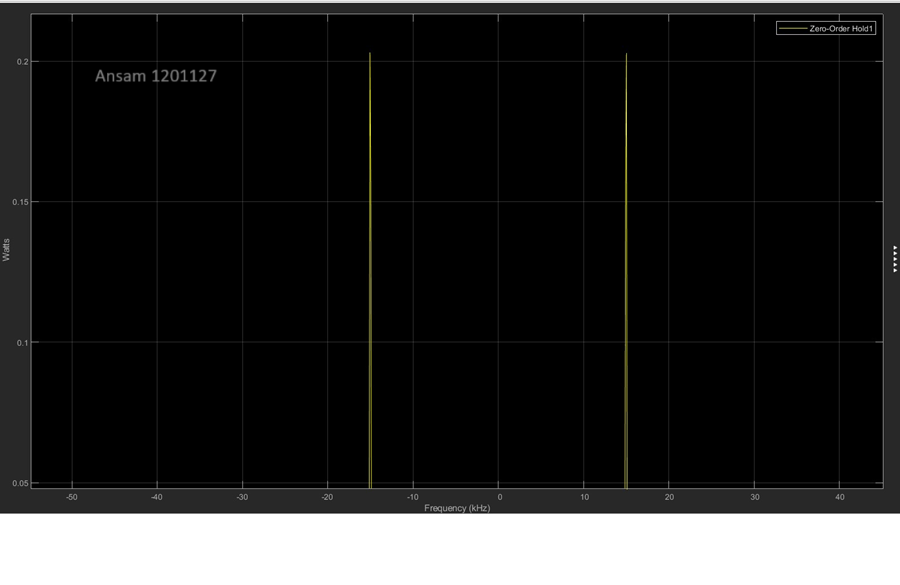


Figure 4:spectrum of c(t)

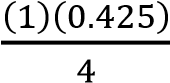
 When **(μ<1)** normal modulation: Ka = 0.5, Am = 0.85 , μ=0.425 Time Domain:

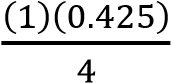
* The mathematical representation of an AM signal in time domain:

s(t) = Ac (1+ka m(t)) cos(2πfc t).

= (1) (1+ μ \*cos(2𝜋(1000)𝑡 )) cos(2𝜋(15𝑘)𝑡)

* The mathematical representation of an AM signal in frequency domain :

S(f) =  [ δ(f− 15k) + δ(f+ 15k)] + (  ) [ δ(f− (16000 ) + δ(f + (16000 )]

+(  ) [ δ(f− (14000 ) + δ(f + (14000) )]

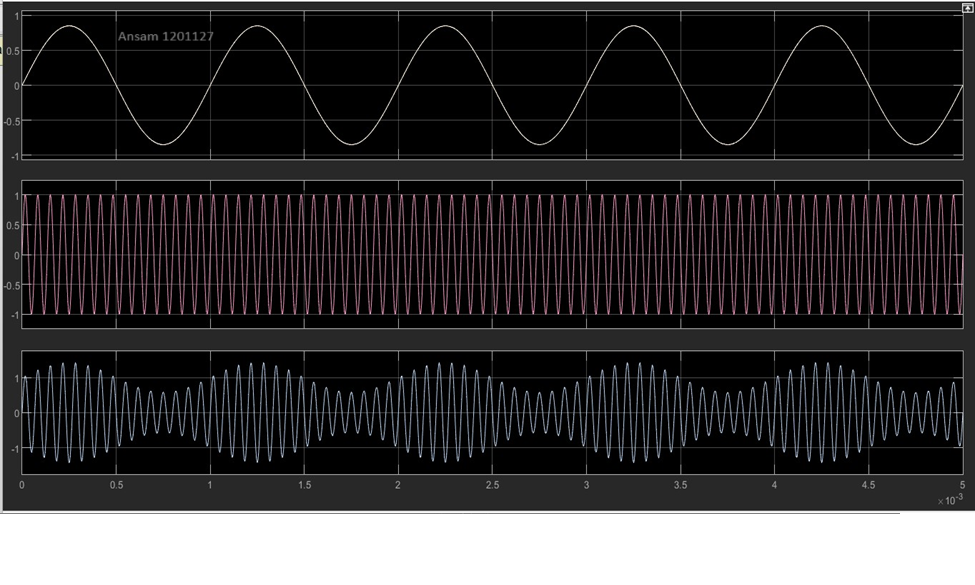


Figure 5:Time domain representation of Am modulation when μ <1

In frequency



Figure 6:frequency

**For (μ=1) :**

Calculating the value of ka μ = ka . Am

ka = ( μ ) / (Am) = ( 1 ) / (0.85) = 1.1765

The mathematical representation of an AM signal in time domain:

s(t)= Ac (1+ka m(t))cos(2πfc t). = (1) (1+ 1.1765 ( 0.85cos(2𝜋(1000)𝑡 )) cos(2𝜋(15𝑘)𝑡)

The mathematical representation of an AM signal in frequency domain :

S(f) = (Ac) /2 [ δ(f− fc) + δ(f+ fc)] + ( (Ac) (μ) /4 ) [ δ(f− (fc + fm ) + δ(f + (fc + fm ) )] + ( (Ac) (μ) /4 ) [ δ(f− (fc - fm ) + δ(f + (fc - fm ) )]

= (1) /2 [ δ(f− 15k) + δ(f+ 15k)] + ( (1) (1) /4 ) [ δ(f− (16000 ) + δ(f + (16000) )] + ( (1) (1) /4 ) [ δ(f− (14000 ) + δ(f + (14000) )]

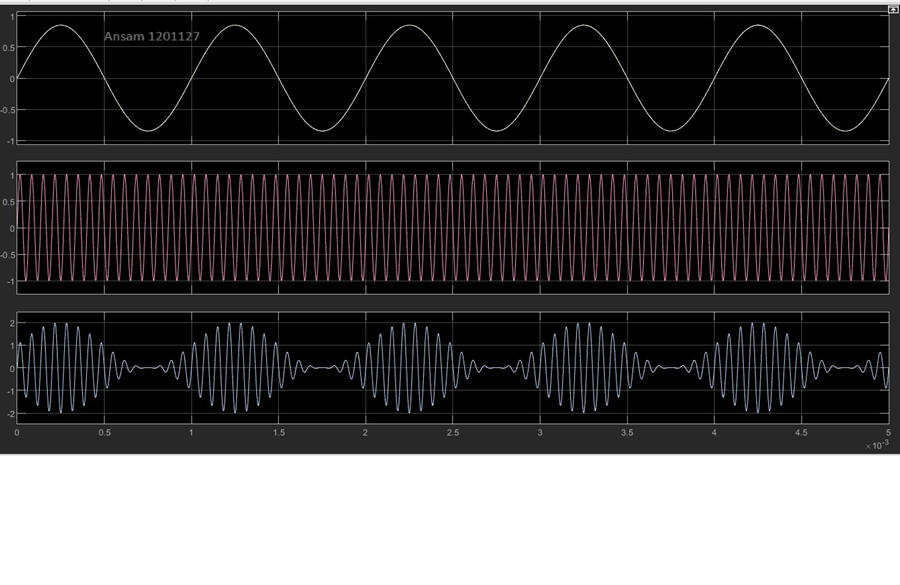


Figure 7:time domain



Figure 8:frequency

**When (μ>1): Ka = 2, Am = 0.85 , μ = 1.7**

The mathematical representation of an AM signal in time domain:

s(t) = Ac (1+ka m(t)) cos(2πfc t).

= (1) (1+ μ \*cos(2𝜋(1000)𝑡 )) cos(2𝜋(15𝑘)𝑡)

The mathematical representation of an AM signal in frequency domain :

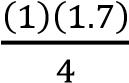
S(f) = 𝐴𝑐 [ δ(f− fc) + δ(f+ fc)]

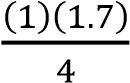
2

+ ( (𝐴𝑐)(𝜇) ) [ δ(f− (fc + fm ) + δ(f + (fc + fm ) )] 4

+ ( (𝐴𝑐)(𝜇) ) [ δ(f− (fc - fm ) + δ(f + (fc - fm ) )]

4

S(f) =  [ δ(f− 15k) + δ(f+ 15k)] + (  ) [ δ(f− (16000 ) + δ(f + (16000 )]

+(  ) [ δ(f− (14000 ) + δ(f + (14000) )]

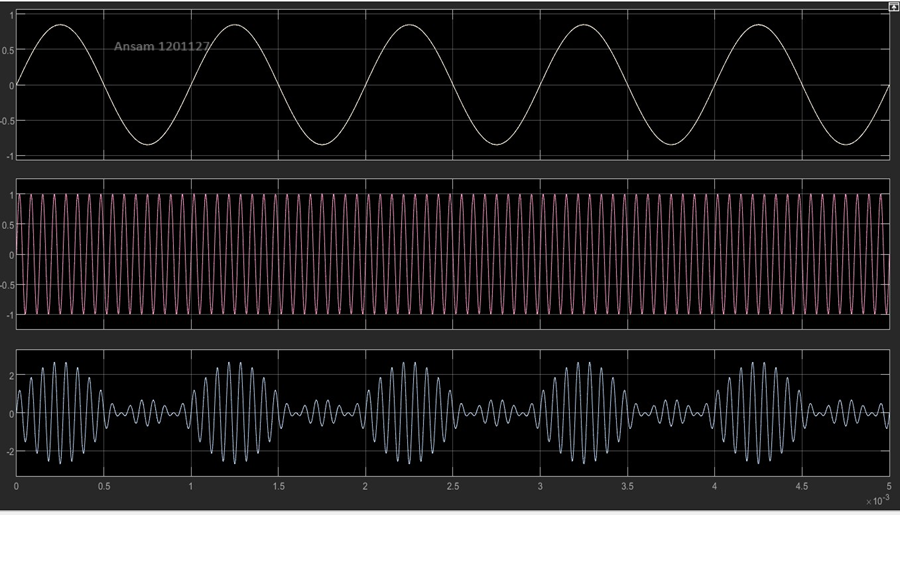


Figure 9:time

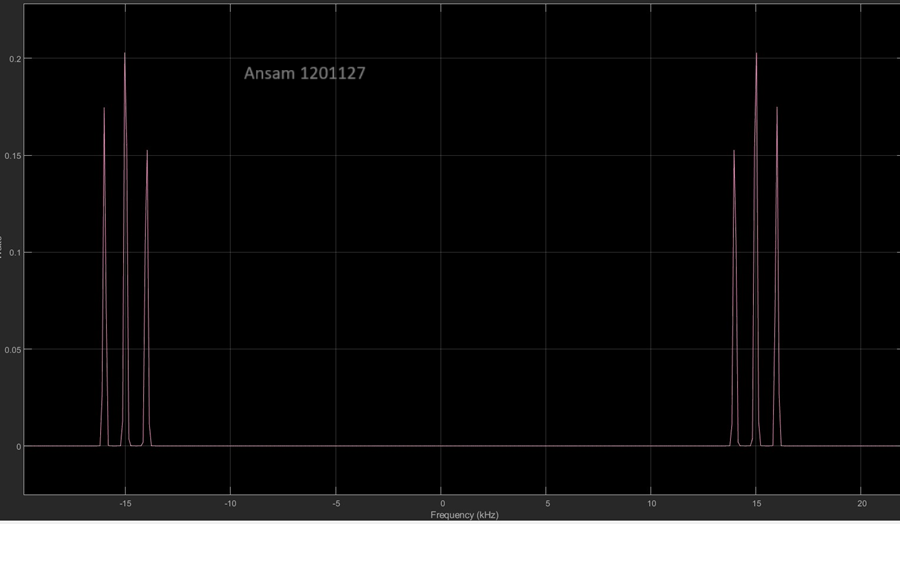


Figure 10:frequency

# **Demodulation:**



1- Coherent Demodulation

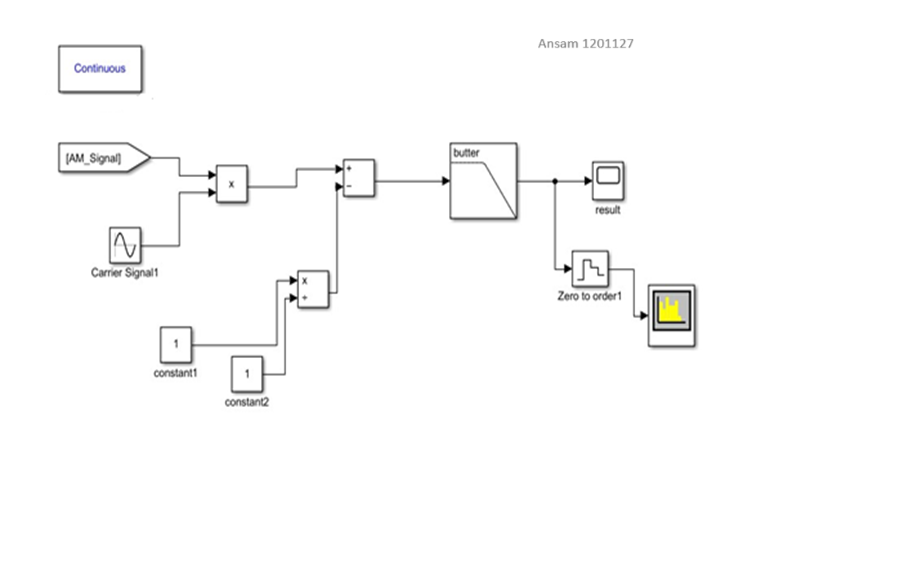


Figure 11:Coherent Demodulation

S’(t)= c(t) \* s(t).

S’(t) =( cos ( 2pi (15 k ) t) ) ( cos ( 2pi (15 k ) t) + 0.5 cos ( 2pi (16k ) t) + 0.5 cos ( 2pi (14k ) t))

=0.5 cos ( 2pi (30k ) t) + 0.5 cos (0) + 0.25 cos ( 2pi (31k ) t) + 0.25 cos ( 2pi (1k ) t) + 0.25 cos

( 2pi (29k ) t) + 0.25 cos ( 2pi (1k ) t)

* M’(t) in time and frequency domain, when ka = 1, under demodulation Time Domain:

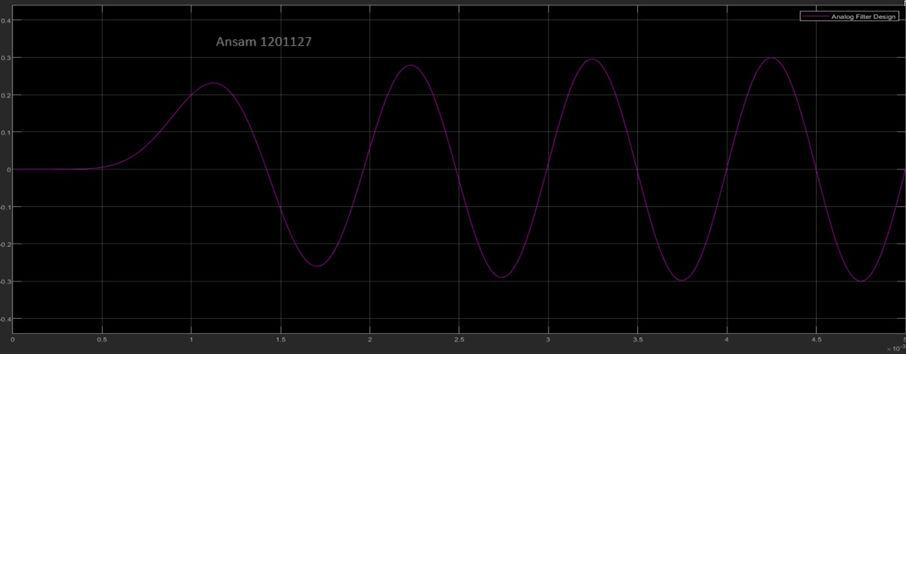


Figure 12:Time domain representation of Coherent Demodulation when μ <1

Frequency Domain Representation:

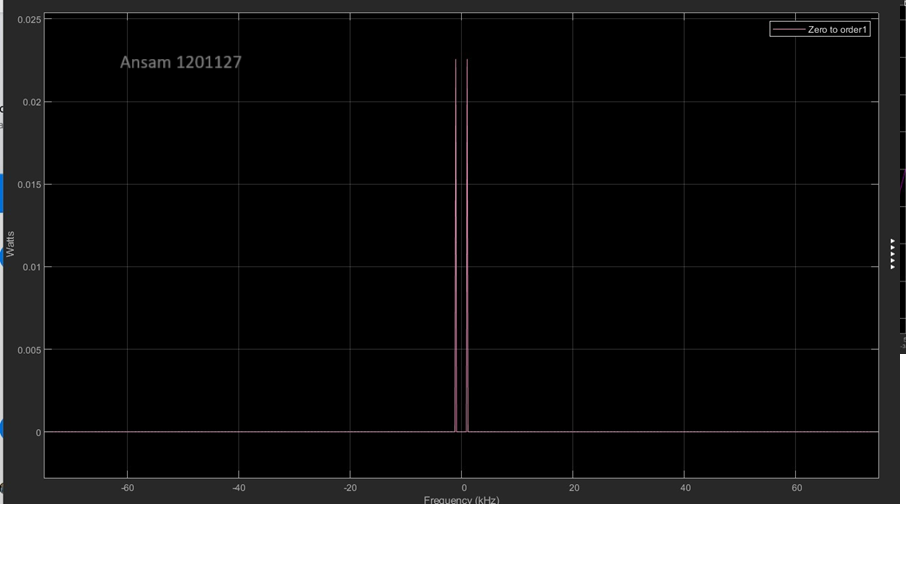


Figure 13:Frequency domain representation of Coherent Demodulation when μ <1

* When (μ = 1): Ka = , Am= 0.85

0.

Time Domain

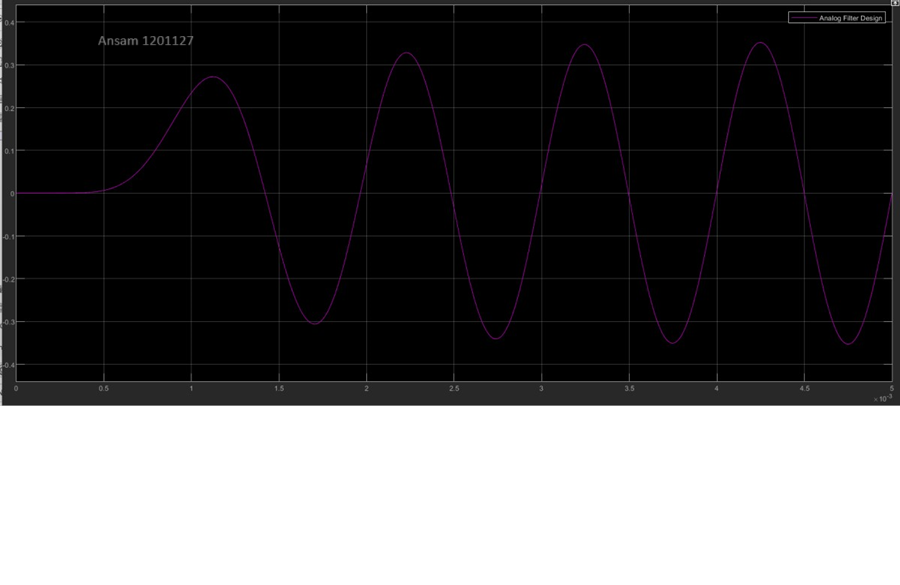


Figure 14:Time domain representation of Coherent Demodulation when μ =1

Frequency Domain Representation:

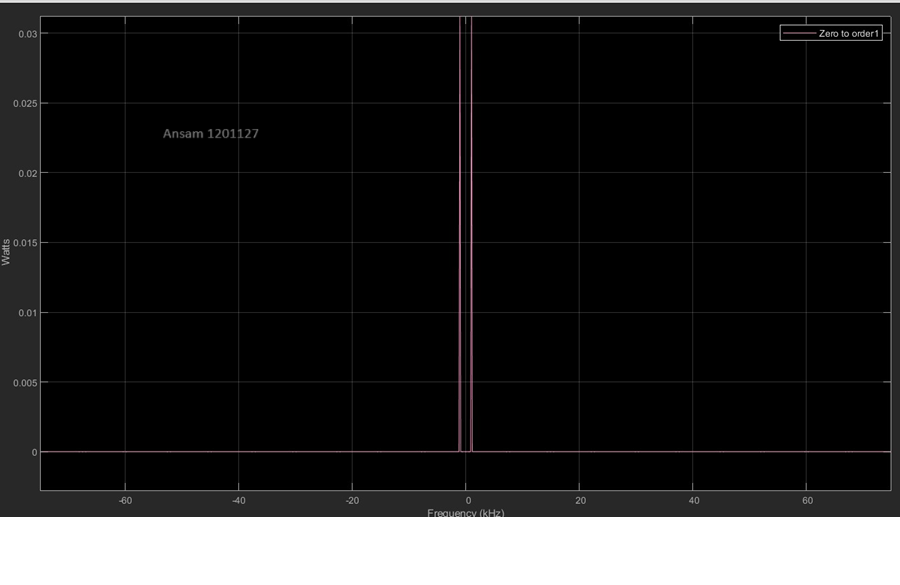
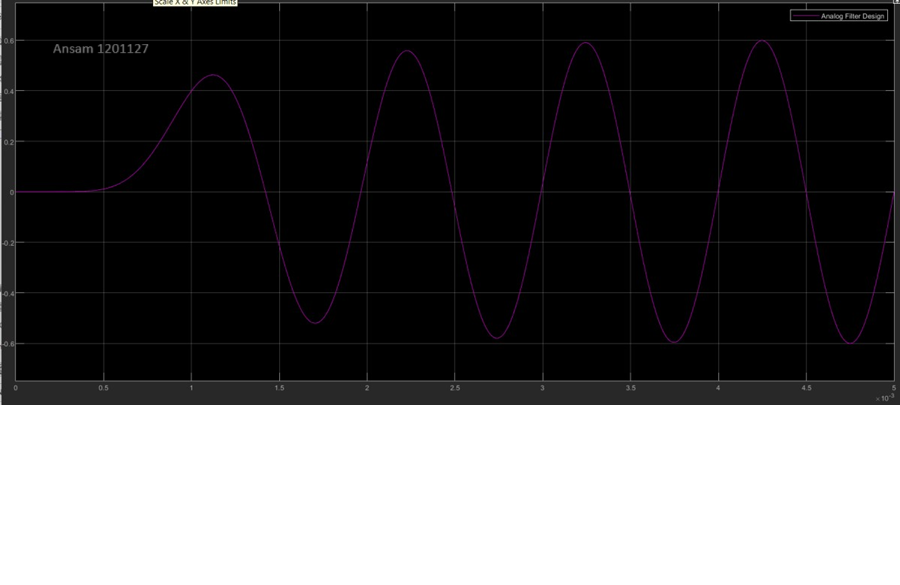


Figure 15:Frequency domain representation of Coherent Demodulation when μ =1

* When (μ>1), time domain: Ka = 2, Am = 0.85 Time Domain:



*Figure 17: Time domain representation of Coherent Demodulation when μ >1*

Frequency Domain Representation:

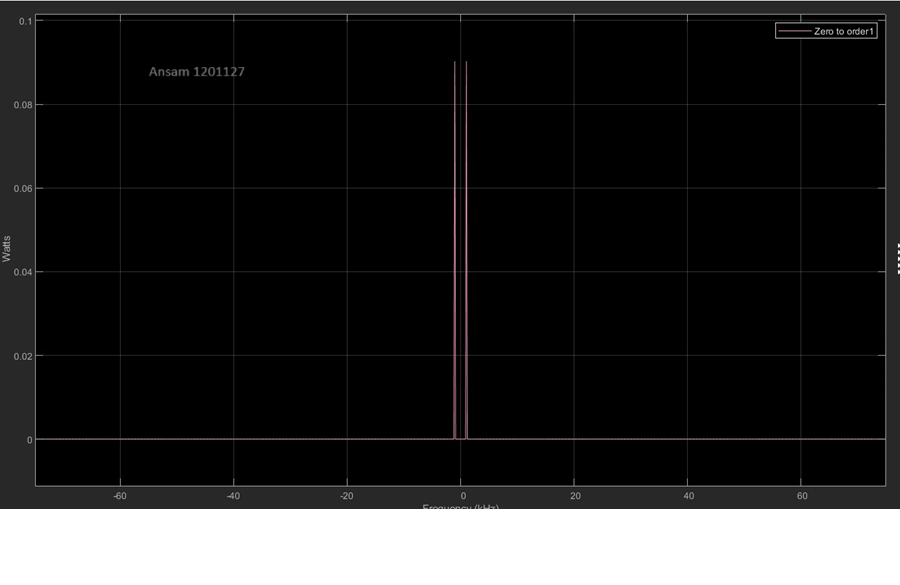


Figure 16:Frequency domain representation of Coherent Demodulation when μ >1

We see in figures apove he output of the demodulation process is equal to the message signal . that’s mean that we get the message signal after demodulation.

# **Envelop detection**

# **demodulation**

Block diagram:

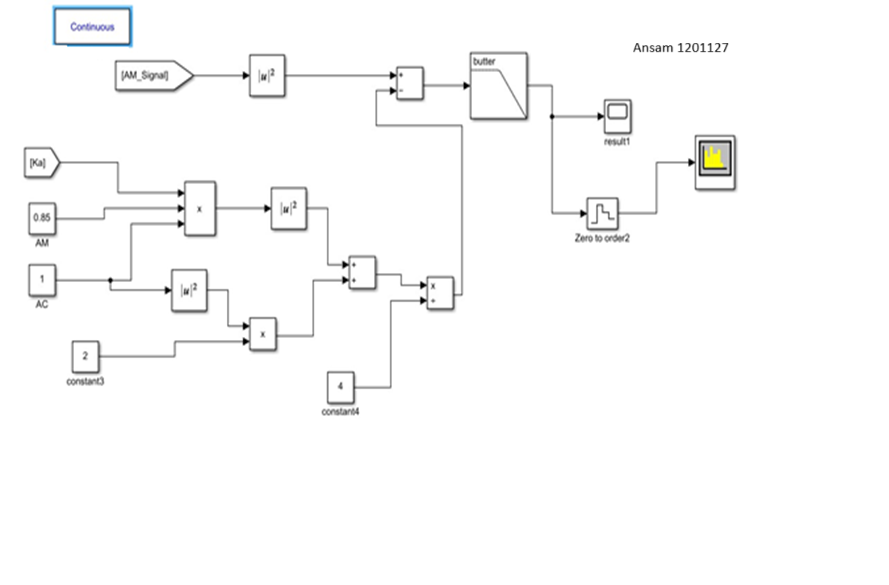


Figure 17:Envelop detection demodulation

M’(t) in time domain when ka=1 and μ <1 under demodulationTime Domain:

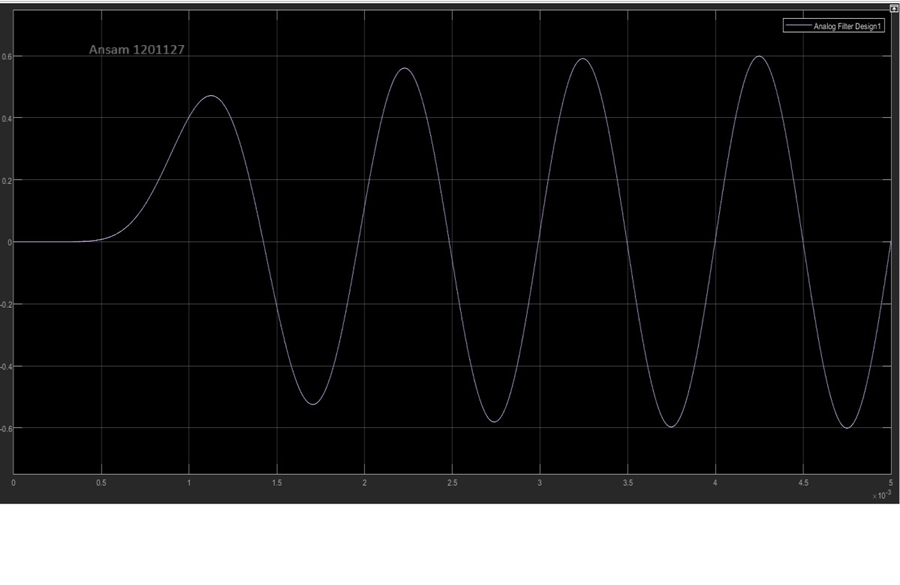


Figure 18:Time domain representation of Envelop detection Demodulation when μ <1

Frequency Domain Representation:

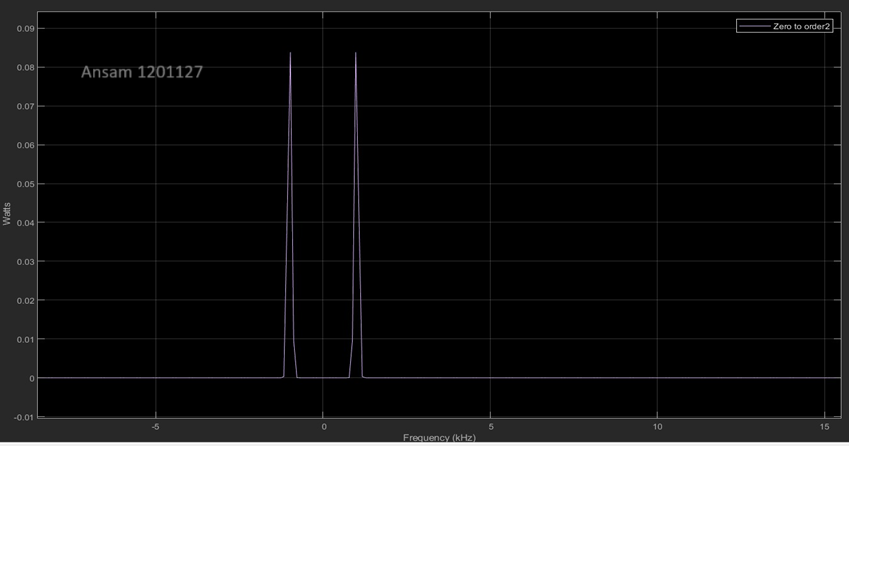


Figure 19:Frequency domain representation of Envelop detection Demodulation when μ <1

When (μ = 1) : Ka = , Am= 0.85

0.

Time Domain:

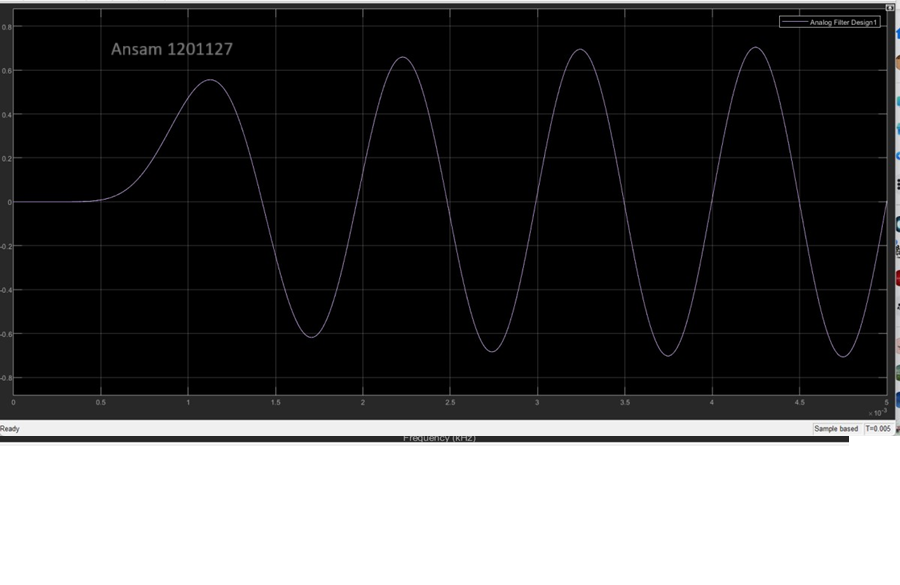


Figure 20:Time domain representation of Envelop detection Demodulation when μ =1

Frequency Domain Representation:

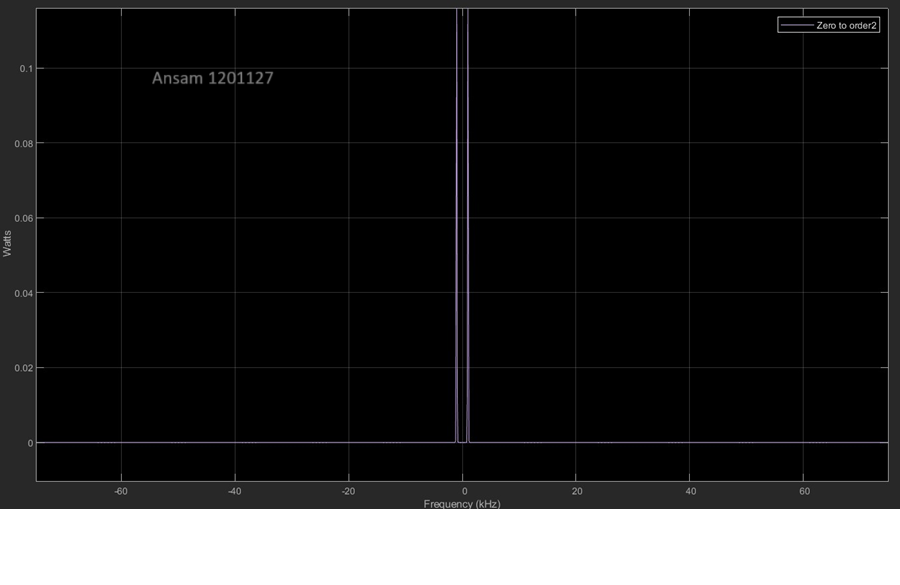


Figure 21: Frequency domain representation of Coherent Demodulation when μ =1

When (μ>1): Ka = 2, Am = 0.85 Time Domain:

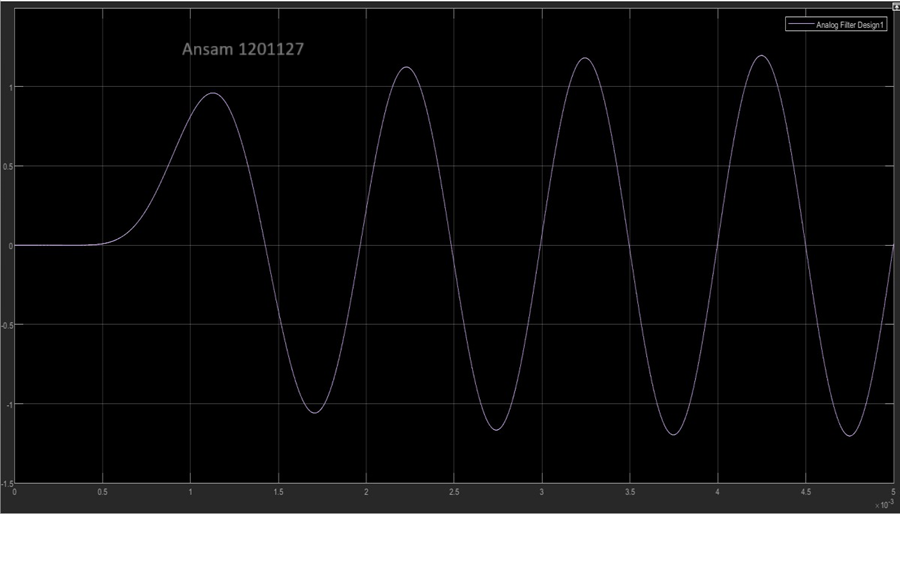


Figure 22Time domain representation of Envelop detection Demodulation when μ >1

Frequency Domain Representation:

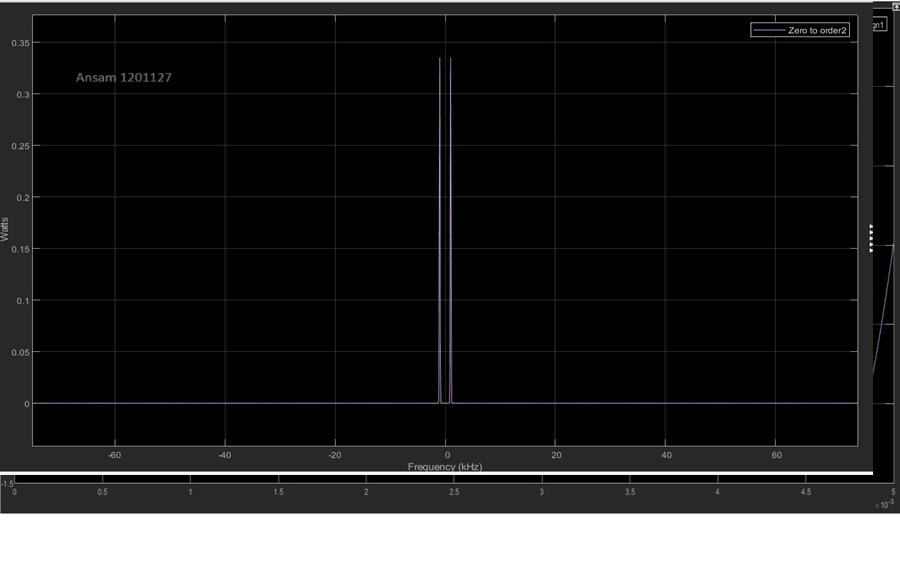
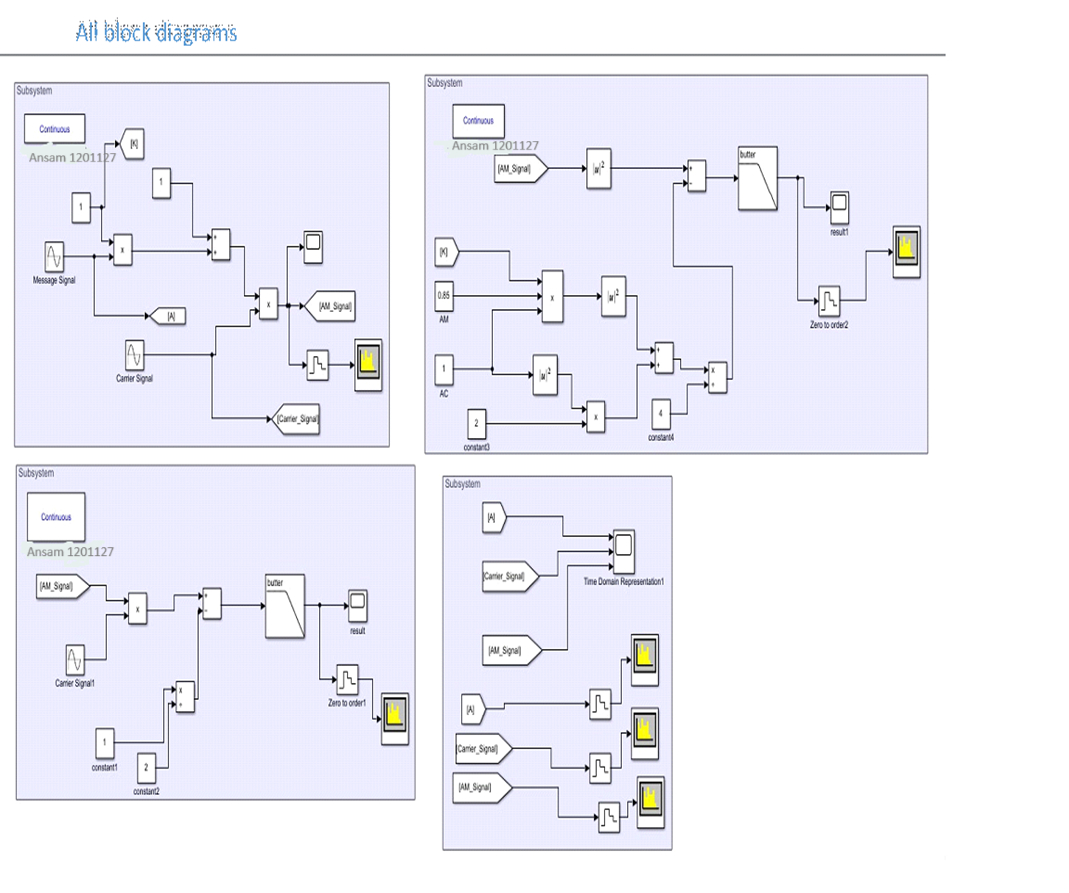


Figure 23:Frequency domain representation of Coherent Demodulation when μ >1





*Figure 26: All Block Diagram*